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PARCHMENT PAPER AS A SOURCE OF MOLD INFECTION IN BUTTER

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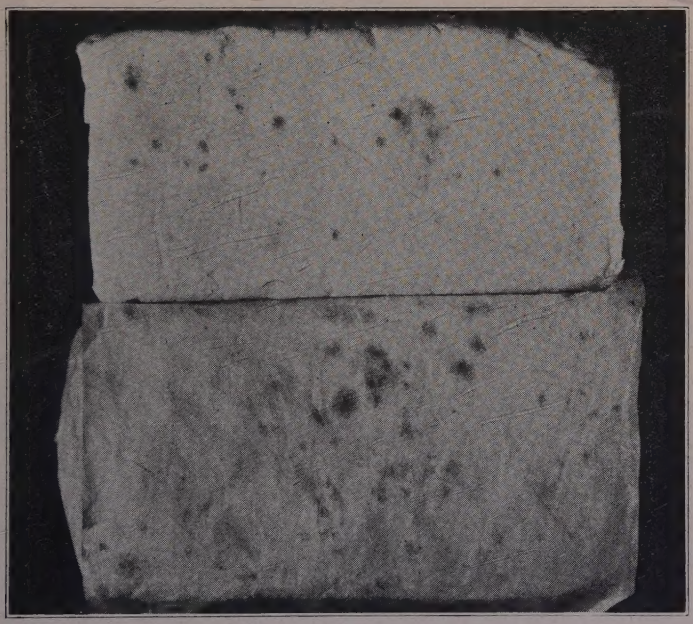

UNIVERSITY FARM, ST. PAUL

PARCHMENT PAPER AS A SOURCE OF MOLD INFECTION IN BUTTER

H. Macy and G. M. Pulkrabek

The butter industry is concerned with every factor that affects the market quality of its product. One of the most disturbing defects of butter on the market is the presence at times of mold spots on the surface and on the wrapper. Among the many possible sources of mold spores, parchment paper has often been suspected. The purpose of the studies reported in this bulletin was to determine whether contaminated parchment paper may be responsible for the molding of butter, and, if so, what methods are most acceptable for avoiding this source of infection.

USE OF PARCHMENT PAPER IN THE BUTTER INDUSTRY

Parchment paper is almost universally used as a wrapper for butter. It is a most acceptable protective covering for such a delicate food product, whether the butter is printed in small units or packed in tubs, boxes, or jars.

The original parchment was an animal product made largely from the skins of sheep. However, the type employed in the food industries, known as vegetable parchment, is made from vegetable material—largely from cotton rag pulp or wood fiber.

MANUFACTURE OF VEGETABLE PARCHMENT

The rag or wood pulps, which are basally cellulose, are carefully purified and bleached. The prepared pulp goes through the regular paper-making process until it evolves as a sheet of paper, called "water-leaf." This paper is then passed through a bath of strong sulphuric acid solution. The acid acts upon the cellulose fibers to form a colloidal substance known as amyloid. This material is rather gelatinous in nature and fills the interstices between the fibers of the paper in such a way that it forms an almost impervious film. Following this acid treatment, the paper is washed several times in pure fresh water to remove all traces of the acid, after which it is dried and cut into convenient sizes for the market.

PROPERTIES OF VEGETABLE PARCHMENT

When the paper is prepared from carefully selected, high-grade raw materials, thoroly purified and washed, it should be odorless and tasteless. The acid treatment renders it tough, semi-transparent, water- and grease-proof. The better quality of vegetable parchment paper is not affected by repeated boiling in water or in concentrated salt solutions. Furthermore, it is practically impervious to gases. These characteristics insure an almost ideal protective covering for butter.

It is desirable that butter should maintain its natural fresh aroma and flavor and its original moisture content. The vegetable parchment paper makes possible a reasonable retention of these properties, inhibits the absorption of undesirable odors from containers or storage rooms, and checks dehydration. As the paper is tasteless and odorless, it does not impart any undesirable flavors to the product. The fact that the paper may be soaked or boiled without modifying its properties is an additional reason why it is peculiarly adapted for use in the creamery, where it may be desirable to use moistened paper or to sterilize it by boiling.

Since the introduction of vegetable parchment, about forty years ago, its use has increased steadily and at present it is practically the only type of paper that comes into direct contact with the surface of butter in packages.

PARCHMENT PAPER AS A SOURCE OF MOLD IN BUTTER

It has been commonly believed in dairy circles that parchment paper may act as a source of mold contamination. Studies that have been made in a number of creameries, and examinations of the paper, have shown that parchment often carries large numbers of mold spores.

In the manufacture of vegetable parchment there is little opportunity for mold spores to survive. The finished paper should not become contaminated in the factory unless it has been washed in impure water or handled carelessly in drying, cutting, or packing for shipment. In most modern factories every precaution has been taken to prevent contamination. It usually leaves the factory in sealed cartons which exclude dust and moisture. Paper from a freshly opened carton seldom is found to be contaminated.

Undoubtedly, the major part of the infection of parchment paper with mold spores takes place in the creamery. The most heavily contaminated paper was found in creameries where it had been removed from the cartons and exposed to dust and dirt on open shelves.

It has been demonstrated conclusively that parchment paper in the creamery is often heavily seeded with mold spores, so it is conceivable

that such paper may, at times, be a factor of considerable importance in the surface molding of butter and the discoloration of the wrapper. Data reported in this bulletin indicate clearly that contaminated paper may lead to serious molding of butter. This being the case, it is important that the user eliminate the possibility of contamination from this source.

Data are here presented to indicate that the mold spores on parchment paper may be destroyed and the parchment be no longer a source of mold.

REVIEW OF LITERATURE

A search of the literature has revealed a number of references which deal with the subject of parchment paper, its effect upon the molding of butter, factors influencing the development of the mold from such a source, and methods for the treatment of the paper to overcome the difficulty. Burr (26, 28, 30) reviews some of the literature and discusses the problem in general. Later, Burr and Wolff (31) make further reference to previous investigations and report some experimental data regarding the part which parchment may play in the surface molding of butter. Gripenberg (39), in a rather extensive way, discusses the importance of parchment paper as a source of mold. Von Boltenstern (73, 74) is of the opinion that parchment is a very slight factor.

While a number of references were found regarding different methods of treating parchment to destroy the mold spores, practically no experimental data are offered to substantiate the statements as to the effectiveness of any one method.

Most of the material upon parchment paper and its relation to the quality of butter has been general in nature. It is not considered sufficiently pertinent to review in detail. However, a rather extensive bibliography which may be useful to some will be found in the appendix. As a matter of convenience, a key to the subject matter covered is included.

EXPERIMENTAL

Parchment Paper as a Source of Mold

In order to determine whether or not contaminated parchment paper may contribute to the molding of butter, a test was made with butter prepared from sterile cream, churned in a sterile churn, handled aseptically, then wrapped in parchment paper that was known to be contaminated with mold spores.

A quantity of cream containing approximately 40 per cent fat was autoclaved at 15 pounds pressure for 20 minutes and cooled to the churning temperature. It was then churned in a sterilized Dazey churn, washed with sterile water, and worked carefully in the glass jar with

sterile ladles. The finished butter contained from 15.4 to 15.6 per cent moisture. No salt was added. Platings made from the autoclaved cream and the finished butter indicated that both were sterile.

The butter was wrapped in contaminated parchment paper with approximately ⅛ pound in each sample. Check samples were wrapped in parchment paper that had been boiled in water for 10 minutes. The wrapped samples were placed in sterile 12-inch desiccator jars provided with cotton-plugged outlets which admitted a constant supply of air. Part of the samples were placed in the cooling room of the experimental creamery at a temperature which fluctuated between 35 and 40 degrees F. The rest were placed in the laboratory refrigerator where the temperature remained almost constantly at 55 degrees F. The samples were observed at various intervals, as indicated in Table I, and precautions were taken to prevent contamination during these examinations. In order to increase the humidity in some of the jars, after a period of storage at ordinary humidities, water was added to the lower chamber of the desiccator jar. Some of the samples originally at 35 degrees F. were later placed at 55 degrees F. in order to stimulate growth if there were any possibility of such activity.

The designation "dry," in Table I, merely indicates the normal humidity of cooler or refrigerator, while "humid" indicates that water had been added to the jar so that the atmosphere in it became saturated with moisture.

Check samples of sterile butter in sterile parchment under all these conditions failed to show any mold even after three months storage.

TABLE I

MOLD DEVELOPMENT ON STERILE BUTTER WRAPPED IN CONTAMINATED PARCHMENT PAPER

Temperature of storage	Total period of storage	Humidity with days of exposure	No. of samples	Samples showing mold spots on	
				Butter	Parchment
° F.	Days			per cent	per cent
35	50	Dry*	12	0	0
35	60	Dry	7	0	0
35	60	50 Dry 10 Humid	5	60.0	0
35	80	60 Dry			
55		20 Dry	7	14.3	0
35	80	50 Dry 10 Humid	5	100.0	60.0
55		20 Humid			
35	100	60 Dry	7	100.0	100.0
55		20 Dry 20 Humid			
55	30	Dry	10	0	0
55	50	Dry	1	100.0	0
55	80	Dry	1	100.0	0
55	80	60 Dry 20 Humid	8	100.0	87.5

* Dry = ordinary humidity; humid = high humidity.

It will be noted that all the other samples wrapped in contaminated parchment became moldy after a period of storage, the mold appearing sooner at high temperatures and high humidities. In most cases the mold spots appeared on both the surface of the butter and the paper, which became badly discolored. From these results it is apparent that a contaminated parchment may, under certain conditions, cause the surface molding of butter. High humidity and temperature unquestionably accelerate the development of the mold.

Treatment of Parchment Paper

As it has been demonstrated that contaminated parchment paper may cause the molding of butter and the discoloration of the paper, it is necessary that some method for destroying the mold spores be applied. In the past, creamerymen have used a variety of methods and substances. In the course of these studies, methods known to be in use were tried as well as some others.

The following were used: (1) Boiling water, (2) boiling supersaturated brine (35 per cent sodium chloride), (3) cold supersaturated brine (35 per cent sodium chloride), (4) cold supersaturated brine (35 per cent sodium chloride) + (35 per cent potassium nitrate). (5) formalin, (6) homemade calcium hypochlorite, (7) commercial sodium hypochlorite, (8) commercial sodium hypochlorite–alkaline sodium phosphate mixture, (9) commercial chloramine preparations 1, 2, 3, and 4, (10) salicylic acid, (11) sodium benzoate, (12) fused boric acid, (13) benzoic acid.

Methods

The methods used for the study of the effect of various preparations upon mold-contaminated parchment paper were as follows: Parchment papers from a variety of sources and known to be infected were cut into approximately 1-inch squares. These papers were then immersed in the solutions under investigation for various periods of time. At the expiration of each period of immersion the paper was removed directly from the solution with sterilized forceps and placed in a sterile petri plate containing 1 cc. of 1 per cent sterile tartaric acid solution. Whey agar was then added and the plates were revolved so as to flood and wash the entire surface of the paper. The paper was left in the solidifying agar. The plates were incubated at room temperature for one week, after which observations were made. Figure 1 illustrates the appearance of such plates.

Exposures to boiling water and to boiling saturated brine were made for 1, 2, and 5 minutes, respectively. With the chemical solutions the exposures were for ½ hour, 1 hour, and 20 hours. The last was

chosen as representing, in creamery practice, a period commonly elapsing from the afternoon of one day until the following morning, when the churning is completed and the packing begun.

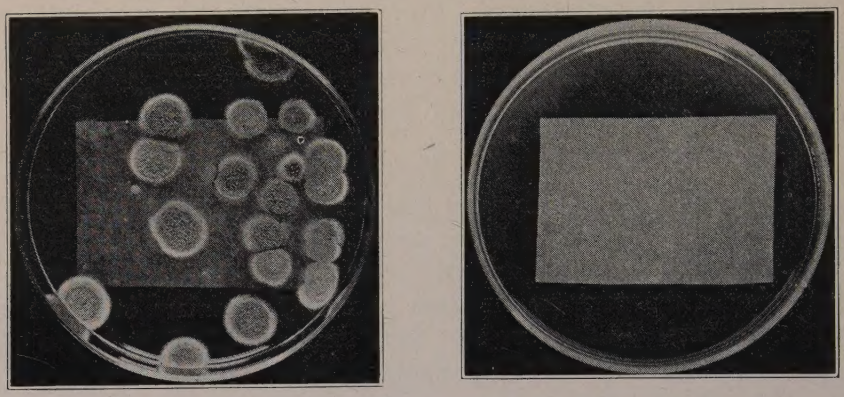

Fig. 1. Testing Parchment Paper for Mold

The cut on the left shows a piece of parchment in nutrient media in a culture dish. The spots are mold colonies, 21 in number, indicating that the piece of parchment carried at least that many mold spores.

The cut on the right shows results after sterilizing a second piece of the same parchment in boiling water.

The results are expressed in percentage efficiency, that is, the percentage of the total number of samples free from mold after being subjected to the particular solution and exposure. If all were sterile after the treatment, the efficiency would be 100 per cent; if none were, the efficiency would be 0 per cent.

The number of samples studied in each case is indicated in each table as well as the concentration of the solution and the time of exposure. With the chlorine preparations, the percentage of available chlorine is given. With dry substances, 1 gram of dry substance was added to 99 cc. of distilled water to make a 1 per cent solution, and in like manner for other concentrations. With the liquid preparations, the solutions were made by volume. The formalin solutions were made from the commercial formalin (a 40 per cent aqueous solution of formaldehyde). The home-made calcium hypochlorite was prepared from a 10-ounce can of chloride of lime. This was made into a paste by the addition of cold water, after which it was diluted with water until a total of 4 liters of water was utilized in making the paste and the dilution. This preparation was mixed thoroly, shaken occasionally during the day, and allowed to stand over night in large flasks. In the morning the clear solution was decanted and the remainder filtered through coarse filter paper. This filtrate became the basic preparation from which the various solutions were made. Commercial

hypochlorite No. 1 was a liquid. Nos. 2 and 3 were powders or crystals containing a combination of sodium hypochlorite and an alkaline cleaning powder. Commercial chlorine No. 1 was in tablet form, Nos. 2, 3, and 4 were powders or crystals.

The results of the experiments are given in Tables II to XVII.

TABLE II

TREATMENT OF PARCHMENT PAPER IN BOILING WATER

No. of trials	Time of exposure	Efficiency
	min.	per cent
16	1	100
16	2	100
16	5	100

Table II indicates that boiling water was remarkably effective, even after short exposures. The mold spores on the most heavily contaminated papers were destroyed in every trial. This method is most satisfactory with parchment that is to be used on unsalted butter.

TABLE III

TREATMENT OF PARCHMENT PAPER IN BOILING BRINE

(35% solution of sodium chloride)

No. of trials	Time of exposure	Efficiency
	min.	per cent
15	1	87
15	2	93
15	5	100

For some unknown reason, the boiling supersaturated brine did not become effective as promptly as the boiling water. However, a 5-minute exposure gave excellent results.

TABLE IV

TREATMENT OF PARCHMENT PAPER IN COLD BRINE

(35% solution of sodium chloride)

No. of trials	Time of exposure	Efficiency
	hr.	per cent
23	½	0
23	1	0
23	20	0

The results given in Table IV contradict the opinion of many creamerymen that a cold supersaturated brine is efficient in the destruction of mold spores on parchment paper. It is absolutely undependable. There is no evidence that any of the mold spores are destroyed even after long exposures to the cold brine. Experiments conducted in these laboratories have indicated that certain types of molds actually thrive and develop in a cold supersaturated brine solution where there are only the merest traces of food materials. If the cold brine does

not destroy the spores or inhibit the growth of certain molds, a contaminated parchment paper soaked in such brine will still be a potential source of mold when it is wrapped about butter, which offers sufficient food for the development of the mold spores. The presence of some concentrated brine on the surface of the paper in contact with butter may check the growth of some molds, but since it does not inhibit all forms, the parchment should be placed in boiling brine to minimize the dangers from contamination. The treatment of parchment with cold brine is an unwise practice.

TABLE V

TREATMENT OF PARCHMENT PAPER IN COLD BRINE

(35% solution of sodium chloride + equal parts of a 35% solution of potassium nitrate)

No. of trials	Time of exposure	Efficiency
	hr.	per cent
10	½	0
10	1	0
20	20	0

The addition of a solution of saltpeter (potassium nitrate) to the cold saturated brine solution was suggested. The results of our trials with this combination are shown in Table V. The mixture was useless from the standpoint of the destruction of mold spores.

TABLE VI

TREATMENT OF PARCHMENT PAPER IN FORMALIN

No. of trials	Strength of solution	Efficiency at various exposures		
		½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent
37	1.0	76	84	100
37	0.5	41	58	84
27	0.4	44	37	85

Table VI gives data to show that formalin is effective in destroying mold spores when a sufficiently strong solution and adequate time are employed. There appears to be a considerable difference in the strength of various commercial samples of formalin. A number of trials besides those reported show that certain samples of formalin were fungicidal in much weaker solutions and in shorter periods of time. Since commercial formalin (which is supposedly 40 per cent formaldehyde in water), varies so much in strength, it is rather questionable whether it may be depended upon for efficient work. It is also known to deteriorate with age.

TABLE VII

TREATMENT OF PARCHMENT PAPER WITH HOMEMADE CALCIUM HYPOCHLORITE

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
18	1.0	0.0216	100	100	100
18	0.5	.....	100	100	100
18	0.25	.....	100	100	89
18	0.2	.....	60	20	20

The results reported in Table VII demonstrate that ordinary homemade calcium hypochlorite is particularly rapid in its action and in rather weak solutions. However, the more dilute solutions lost some of their fungicidal power after standing. This deterioration after exposure to light, air, time, and use is often rapid, especially in weak solutions. The solutions must be freshly prepared or sufficiently fortified with concentrated solutions to maintain their destructive power against mold spores.

TABLE VIII

TREATMENT OF PARCHMENT PAPER WITH SOLUTIONS OF COMMERCIAL SODIUM HYPOCHLORITE

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
24	2	0.1666	100	60	100
24	1	.....	96	96	96
24	0.5	.....	96	92	80
24	0.2	.....	89	22	45
24	0.1	.....	45	50	67

The results given in Table VIII show that these solutions of commercial sodium hypochlorite were not particularly dependable. Even with a higher chlorine percentage than that of the homemade calcium hypochlorite solution, the efficiency was not so great. Its power as a fungicide seemed to be questionable.

TABLE IX

TREATMENT OF PARCHMENT PAPER WITH A SOLUTION OF A COMMERCIAL MIXTURE–SODIUM HYPOCHLORITE–ALKALINE SODIUM PHOSPHATE

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
25	4	0.3873	92	56	92
19	2	.....	74	53	68
29	1	.....	62	66	62
10	0.5	.....	60	40	80
10	0.2	.....	80	60	40
20	0.1	.....	75	70	45

This mixture of sodium hypochlorite and alkaline sodium phosphate was not reliable in any of the solutions prepared. Even in the costly

4 per cent solution, as Table IX indicates, the results were not satisfactory, regardless of the fact that the percentage of available chlorine was more than ten times as great as in the homemade hypochlorite solution. These trials make doubtful the usefulness of such a preparation for the destruction of mold spores on parchment paper.

TABLE X

TREATMENT OF PARCHMENT PAPER WITH COMMERCIAL CHLORAMINE NO. 1

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
11	0.4	0.3190	100	100	100
11	0.2	.....	100	100	100
11	0.1	.....	82	82	100

This solution of a commercial chloramine compound was remarkably effective, as illustrated in Table X, especially in the more concentrated solutions.

TABLE XI

TREATMENT OF PARCHMENT PAPER WITH COMMERCIAL CHLORAMINE NO. 2

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
15	1	0.6556	100	100	100
15	0.8	.....	100	100	100
15	0.6	.....	100	100	100
15	0.4	.....	20	20	33
15	0.2	.....	40	12	53

Table XI gives the results of trials with another chloramine preparation. It will be noted that there is a rather abrupt division between effective and non-effective strengths. This is unusual, but illustrates that a danger line is easily reached.

TABLE XII

TREATMENT OF PARCHMENT PAPER WITH COMMERCIAL CHLORAMINE NO. 3

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
29	1	.03156	93	100	100
29	0.5	.....	100	100	100
29	0.25	.....	92	100	100
19	0.1	.....	32	26	53

In the case of commercial chloramine No. 3, the results are quite satisfactory. Table XII shows that it requires somewhat more time for action than Nos. 1 and 2. Again there is the sharp line of demarcation between the satisfactory and the unsatisfactory concentrations.

TABLE XIII

TREATMENT OF PARCHMENT PAPER WITH COMMERCIAL CHLORAMINE NO. 4

No. of trials	Strength of solution	Available chlorine	Efficiency at various exposures		
			½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent	per cent
10	1	0.8860	80	40	100
20	0.5	.....	40	50	70
10	0.2	.....	0	30	80
10	0.1	.....	0	0	0

Of all the chloramine solutions studied, No. 4 was least effective. The absolutely negative results of certain strengths, as shown in Table XIII, are rather unusual, especially when the percentage of available chlorine is so high.

TABLE XIV

TREATMENT OF PARCHMENT PAPER WITH SALICYLIC ACID

No. of trials	Strength of solution	Efficiency at various exposures		
		½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent
10	1	100	100	100
10	0 5	100	100	100
10	0 25	100	100	100
10	0 1	100	100	100

The results obtained when using solutions of salicylic acid (Table XIV) prove that this substance is a very powerful fungicide. In every case, the mold spores were destroyed. Even tho it is effective, its use for treating parchment can not be recommended because of difficulties to be encountered from pure food laws.

TABLE XV

TREATMENT OF PARCHMENT PAPER WITH SODIUM BENZOATE

No. of trials	Strength of solution	Efficiency at various exposures		
		½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent
10	1	70	80	90
10	0.5	30	50	40
10	0.25	50	30	50
10	0.1	10	20	10

Even tho sodium benzoate is a common and effective food preservative it did not have sufficient strength in the solutions listed in Table XV to destroy all the mold spores on the parchment. Its use is open to the same objections as is the use of salicylic acid.

TABLE XVI

TREATMENT OF PARCHMENT PAPER WITH FUSED BORIC ACID

No. of trials	Strength of solution	Efficiency at various exposures		
		½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent
10	5	100	100	100
10	4	0	0	40
10	3	0	0	20
20	2	0	0	35
30	1	10	3	7
30	0.5	7	3	3
30	0.25	3	3	3

Altho a 0.5 per cent solution of boric acid has been recommended for treating parchment paper, the results recorded in Table XVI show that it is very ineffective. Excessively high concentrations are necessary to exert any noticeable effect upon the contaminated parchment. The element of time enters into its efficiency. Its use is not recommended.

TABLE XVII

TREATMENT OF PARCHMENT PAPER WITH BENZOIC ACID

No. of trials	Strength of solution	Efficiency at various exposures		
		½ hr.	1 hr.	20 hr.
	per cent	per cent	per cent	per cent
10	1	100	100	100
10	0.5	100	100	100
10	0.2	60	100	100
10	0.1	10	40	100

Benzoic acid appeared to be a powerful fungicide when in sufficiently concentrated solutions. Table XVII shows that time is a factor in its action. However, in the concentrations necessary to destroy mold spores, some of the benzoic acid is precipitated out of solution into a crystalline or flaky form which is very apparent on the surface of the paper. This is objectionable and eliminates benzoic acid as a satisfactory substance for treating parchment even tho it is an effective agent against the mold spores.

DISCUSSION OF RESULTS OF TREATING PARCHMENT PAPER BY VARIOUS METHODS

It is well to consider the significance of the results obtained with various methods for the destruction of mold spores on parchment paper. (1) The purpose of treating the paper is to destroy the mold spores. The most effective method should be sought. (2) The more quickly the destruction is accomplished, the more satisfactory is the method. (3) The results must be accomplished without introducing any deleterious substance on the surface of butter, and without endangering

the health or well-being of the person using the method. (4) The method must be practical and economical.

From the standpoint of destructive ability, many of the chemical preparations rank high. None, however, are any more certain than boiling water or boiling brine. Water is always of the same concentration, so introduces no difficulties as to strength. Brine solutions may vary in strength but one can never get more than a certain amount of salt into solution in water. After the saturation point is reached the excess settles out. Even if the concentration of the brine is not constant, boiling overcomes that deficiency. In fact, the killing effect lies not in the salt but in the high temperature reached in boiling the solution. With the chemicals, however, effectiveness depends upon the strength of the solution. Hypochlorite solutions are very likely to lose their strength upon standing. Light, heat, and air have a decidedly detrimental effect upon them, especially when they are in dilute solution. Even the concentrated solutions deteriorate with age. For this reason an operator can seldom be sure that the solution he is using is sufficiently concentrated to accomplish his purpose. Also, dilution of these solutions or of any other chemicals lessens their power.

The combinations of hypochlorites and alkalies have a better keeping quality than the hypochlorites alone, especially as they are usually dry substances, which deteriorate much more slowly than liquids. However, their efficiency as fungicides was found to be low.

The chloramines are practically all sold in powder or crystalline form. In solution they often increase in strength, as measured by the chlorine percentage after evaporation. This is not true if they are diluted. But it must be borne in mind that the percentage of available chlorine is not the sole criterion of the effectiveness of a chlorine preparation, as the data show.

The fact must also be considered that continued use of a chemical solution will weaken it. If chlorine, oxygen, or any other element must take part in a sterilizing action, the strength must decrease with repeated use of the solution. This is a very important point when determining the satisfaction which any chemical preparation will give in practice. Unfortunately, the average creamery is not equipped to test the strength of solutions day by day, hence there is a possibility that a solution may be useless before the operator is aware of the fact.

The rapidity with which a given method will accomplish its purpose is a factor under practical conditions. An operator may wish to treat a supply of parchment in an emergency. If he must wait one hour or twenty hours the delay will be costly and often results in no treatment. Of all the methods, the boiling water is most expedient. Water is conveniently at hand, and in an average creamery there is

always plenty of steam or a source of heat for boiling the water if the boiling water itself is not always available. Five or ten minutes in boiling water is decidedly effective in destroying mold spores. Boiling brine is almost equally convenient and efficient.

When chemicals are resorted to for treating parchment paper, difficulties beyond those already mentioned may arise. The odor of formaldehyde is disagreeable. It causes the eyes to smart and the hands to become dry and cracked. Chlorine solutions may bleach the surface of the butter. Benzoic acid in the necessary strength crystallizes out on the surface of the paper. Most important, however, is the fact that chemicals on the paper may be absorbed by the butter. The pure food officials may then deem the butter adulterated. Seizures, fines, and embarrassment may be the result. Water and salt are not objectionable and their use is not illegal unless there is too much water in the butter because of faulty methods of manufacture. Not enough water is added with the parchment to constitute adulteration.

The cost of many of the chemicals is a factor to be considered. If a solution is kept up to strength, more of the chemical must continually be added or else the solution must be discarded and renewed. Water and salt are cheap and always available.

Altogether, it appears that boiling water and boiling brine are by far the most satisfactory for treating parchment paper for the elimination of mold spores.

RESULTS OBTAINED WITH TREATED PARCHMENT

After the trials of various methods for treating parchment paper, studies were made to determine if contaminated parchment treated by the most efficient methods would actually be rid of the mold spores and not produce moldy areas on the surface of butter, or if traces of the solutions used would have any protective effect.

Experiment 1

A batch of raw cream was churned in a sterile Dazey churn. An analysis of the finished butter revealed a few white molds, presumably *Oidium lactis*, but no colored types. The butter was wrapped in parchment paper that before treatment was badly contaminated with a variety of molds. The papers were treated by the most efficient methods previously reported, and indicated in Table XVIII. A check sample was wrapped in untreated parchment.

The samples were then stored at 35 and 55 degrees F. under conditions similar to those described on foregoing pages.

The results are given in Table XVIII, in which "B" indicates that the butter exhibited areas of mold; "BP" that both butter and parch-

ment were moldy, and "O" that there were no visible signs of moldiness on either. The term "dry" in the headings indicates that the samples were stored at the ordinary atmospheric humidities, while "humid" means that the butter was subjected to an atmosphere saturated with moisture. The latter condition was accomplished by the addition of water to the bottom of the covered jar, as already described.

TABLE XVIII

RESULTS OBTAINED WITH TREATED PARCHMENT PAPER

(Raw cream butter with low mold content wrapped in parchment treated by various methods)

Treating medium	Strength of solution	Time of exposure	Appearance of mold spots after storage			
			50 days dry at 35° F.	60 days dry at 35° F. + 20 days humid at 55° F.*	50 days dry at 55° F.*	60 days dry + 20 days humid at 55° F.*
	per cent	hr.				
Check—untreated	..	..	O	B	O	BP
Boiling water	..	5†	O	O	O	O
Boiling brine	35.0	5†	O	O	O	O
Calcium hypochlorite	0.5	½	O	O	O	O
Commercial sodium hypochlorite	2.0	½	O	O	O	O
Commercial sodium hypochlorite + alkali	4.0	½	O	O	O	O
Commercial chloramine 1	0.2	½	O	O	O	O
Commercial chloramine 2	0.5	½	O	O	O	O
Commercial chloramine 3	0.6	½	O	B	O	B
Boric acid	5.0	½	O	O	O	O
Salicylic acid	0.1	½	O	O	O	O
Sodium benzoate	1.0	20	O	O	O	O
Formalin	1.0	20	O	O	O	O

* B = mold on butter, BP = mold on both butter and parchment, O = no mold on either.
† Minutes.

The parchment paper used in the experiment reported in Table XVIII was known to be highly contaminated with mold spores before it was treated. The results with the check sample substantiate those obtained in earlier trials with infected paper. With the exception of the results obtained with commercial chloramine No. 3, none of the butter wrapped in treated parchment exhibited any signs of mold spots even tho the same lots of paper before treatment had invariably produced moldiness. The butter wrapped in paper treated in the chloramine No. 3 solution had just one small area of mold, which might have been the result of an accidental contamination in the handling of the sample and not of an inefficient solution. The fact, necessarily, was reported. The effect of humidity may again be seen.

Experiment 2

The question naturally arose as to the possibility that the chemical solutions used for treating parchments might be carried into contact with the butter and exert a residual, inhibiting effect upon the develop-

ment of molds on the surface of the butter when the butter itself was known to be contaminated.

A sample of raw cream was inoculated with cultures of green and black molds (*Penicillium sp.* and *Aspergillus sp.*). It was later churned in a Dazey churn. The butter was wrapped in parchment paper treated by the methods already mentioned. A check sample was carried in untreated paper. As before, the butter was stored at 35 and 55 degrees F. Half of the samples at each temperature were left in the jars at ordinary humidity, while the rest were in jars, the bottoms of which were filled with water to yield higher humidity. Table XIX sets forth the results obtained in this study.

TABLE XIX

PROTECTIVE EFFECT OF TREATED PARCHMENT

(Butter contaminated with mold and wrapped in treated parchment)

Treating medium	Strength of solution	Time of exposure	Appearance of mold after 6 weeks' storage*			
			Low humidity		High humidity	
			35° F.	55° F.	35° F.	55° F.
	per cent	hr.				
Check—untreated	..	..	B	B	BP	BP
Boiling water	..	5†	B	B	BP	BP
Boiling brine	35.0	5†	B	B	BP	BP
Cold brine	35.0	20	B	B	BP	BP
Benzoic acid	0.5	½	B	B	B	BP
Boric acid	5.0	½	B	B	BP	BP
Formalin	1.0	20	B	B	BP	BP
Salicylic acid	0.1	½	B	B	BP	BP
Sodium benzoate	1.0	20	B	B	BP	BP
Calcium hypochlorite	0.5	½	B	B	BP	BP
Commercial sodium hypochlorite	2.0	½	B	B	BP	BP
Commercial sodium hypochlorite + alkali	4.0	½	B	B	BP	BP
Commercial chloramine 1	0.2	½	B	B	BP	BP
Commercial chloramine 2	0.5	½	B	B	BP	BP
Commercial chloramine 3	0.6	½	B	B	BP	BP

* B = mold on butter, BP = mold on both butter and parchment.

† Minutes.

In all cases, the butter became moldy after six weeks storage at both 35 and 55 degrees F. The samples kept at high humidity were not only moldy on the surface, but the paper itself was badly spotted and discolored with the mold growth that overran it. There was one exception to the latter condition. The sample wrapped in paper treated with benzoic acid did not show any mold on the paper. Crystals of benzoic acid covered the surface and apparently checked the growth on the paper.

These experiments have demonstrated clearly that if butter is so made that it is free from mold (particularly certain types) and wrapped in properly treated parchment, it is reasonably safe from the possibility

of molding. On the other hand, if butter is heavily contaminated with mold, the treated parchment, even if it carries salt or other chemicals on its surface, has no marked protective effect against the development of mold. The destructive power of the chemical is lost by dilution or decomposition, in all probability.

Furthermore, it must be borne in mind that the appearance of mold spots on the surface of the butter does not necessarily incriminate the parchment paper. The source of moldiness may be the butter itself, in which case the parchment paper, itself free from mold, may be badly spotted and discolored by mold growth. Consequently there must be not only an adequate treatment of the parchment paper, but also an application of thoro sanitation in the care and handling of the cream and butter throughout the manufacturing process.

CONCLUSIONS

1. Areas of distinct, visible mold growth may be produced on the surface of a mold-free butter by infection with spores brought into contact with the butter by contaminated parchment paper.

2. Parchment paper contaminated with mold spores may be considered as an important potential source of mold on the surface of butter.

3. Moldy areas resulting from the use of contaminated parchment paper may develop not only on the butter but also on the paper, producing an undesirable discoloration.

4. Several weeks often elapse, depending largely upon humidity and temperature, before the growth of mold becomes visible to the naked eye as deeply colored areas on the butter or parchment.

5. Contaminated parchment paper may be rendered mold-free by simple treatment.

6. The simplest and most satisfactory treatment for the destruction of mold spores on parchment paper is complete immersion of the paper in *boiling* water or *boiling* brine (supersaturated sodium chloride solution) for *at least five minutes*.

7. A number of chemicals, when in sufficiently concentrated solutions and when allowed to act for sufficient periods of time, destroy mold spores, but the objections to their use are such that none of them are recommended.

8. Evidence is presented to show that when contaminated parchment papers undergo an effective treatment they are no longer sources of mold.

9. Traces of chemicals which may remain on the parchment papers after treatment by the methods described do not inhibit the growth of the mold on the surface of butter when the butter itself is the source

of the mold, nor do these methods of treatment prevent the occurrence of moldy areas on the parchment paper.

10. The proper treatment of parchment paper, preferably by boiling water or boiling brine, is an absolutely essential part of the manufacturing process in a creamery producing butter of the highest market quality.

BIBLIOGRAPHY

For the convenience of those who wish to make use of the accompanying bibliography, a brief index on the basis of the subject matter is given below.

Manufacture of parchment paper: 6, 22, 35, 38, 41, 46, 48, 50, 58, 71, 76.

Mold on wood, wood pulp, and paper containers: 7, 36, 51, 65.

Parchment paper and its use for wrapping butter: 3, 4, 8, 20, 21, 23, 26, 27, 28, 29, 30, 31, 32, 33, 37, 39, 56, 61, 62, 64, 66, 67, 70, 72, 73, 74, 75.

Sugar or sirup on parchment paper: 4, 26, 27, 30, 31, 32, 40, 54, 61, 62, 64, 67, 73, 74, 75.

Glycerin on parchment paper: 4, 26, 31, 61.

Other chemicals found in or on parchment paper and defects caused by them: 2, 4, 10, 11, 17, 21, 25, 26, 27, 28, 29, 32, 37, 49, 56, 72, 75.

Treatment of parchment paper: 3, 5, 23, 30, 31, 33, 34, 37, 39, 42, 47, 59.

Properties and testing of parchment paper, and miscellaneous: 1, 2, 8, 12, 13, 14, 15, 16, 17, 18, 19, 24, 32, 38, 40, 43, 44, 48, 52, 53, 55, 57, 60, 63, 67, 68, 69, 75.

1. Annoni, G. and Rodano, G. Tests for distinguishing parchment paper from pergamyn paper. Ann. Lab. Chim. delle Gabelle, **7**:19. 1914. Abstract in Jour. Soc. Chem. Indus. **34**:487. 1915.
2. Anon. Parchment paper turning yellow. Papier Ztg. **21**:34. 1896. Abstract in Jour. Soc. Chem. Indus. **15**:370. 1896.
3. ————. Mold on butter (Translated title). Maelkeritid. **17**:437. 1904.
4. ————. Parchment paper for use in wrapping butter. Papier Ztg. **32**:2300-2391. 1907. Abstract in Chem. Abstracts **1**:2633-2634. 1907.
5. ————. Meeting the mold menace. Butter Merchandising. Paterson Parchment Paper Co. p. 3. April, 1924.
6. ————. Manufacture of parchment paper. Wochbl. Papierfabr. **42**:3055-3057. 1911. Abstract in Chem. Abstracts **5**:3908. 1911.
7. Barnes, F. Mold growths on wood pulp. Pulp Paper Mag. Can. **10**:27-29. 1911.
8. Bartsch, C. Fettdichtigkeit von Pergamentpapieren. Mitt. K. Materialprufungsamt. **22**:290-291. 1904.
9. ————. Methods of testing the impermeability of parchment paper to fats. Papier Ztg. **30**:2190. 1905. Abstract in Jour. Soc. Chem. Indus. **24**:854-855. 1905.
10. ————. Einwirkung schwacher Alkalinilösungen auf chlormagnesiumhaltige Pergamentpapiere. Mitt K. Materialprufungsamt. **24**:59. 1906.
11. ————. Chlormagnesiumhaltige Pergamentpapiere. Mitt. K. Materialprufungsamt. **25**:26. 1907.
12. ————. Vorbereitung von Pergamentpapier für die mikroskopische Untersuchung. Mitt. K. Materialprufungsamt. **25**:235-236. 1927.

13. ———. Einflusz höherer Wärmegrade auf die Festigkeitseigenschaften von Pergament-, Pergamentersatz- und Pergamynpapieren. Mitt. K. Materialprufungsamt. 25:237-244. 1907.
14. ———. Prüfung der Fettdichtigkeit von Pergamentpapieren. Mitt. K. Materialprufungsamt. 25:303. 1917.
15. ———. Neutralisierte Pergamentpapiere. Mitt. K. Materialprufungsamt. 25:303-307. 1907.
16. ———. Vorbereitung von Pergamentpapier für die mikroskopische Untersuchung. Mitt. K. Materialprufungsamt. 29:61-62. 1911.
17. ———. Einflusz der Erwärmung und Lagerung auf chlormagnesiumhaltige Pergamentpapiere. Mitt. K. Materialprufungsamt. 30:400-404. 1912.
18. ———. Dauerversuche mit Pergament-, Pergamentersatz- und Pergamynpapieren. Mitt. K. Materialprufungsamt. 32:510-518. 1914.
19. ———. Die Bestimmung der Fettdichtigkeit von Pergamentersatz- und Pergamynpapieren. Mitt. K. Materialprufungsamt. 33:441-445. 1915. Also 35:52-57. 1917.
20. Berg, P. Noch einiges über Pergamentpapier. Ztschr. Untersuch. Nahr. u. Genussmtl. 24:518. 1912.
21. Beythien, A., Hempel, H., and Borisch, P. Butteruntersuchungen. Bericht d. Untersuchungsamtes Dresden, 9. 1903.
22. Blücher, H. Modern Industrial Chemistry. Berlin. 1911.
23. Böggild, B. Skimlede dritler og skimlet pergament. Maelkeritid. 17:483-488. 1904.
24. Böttger, T. Pergamentpapier. Chem. Tech. Repertorium. 11:159. 1874.
25. ———. Farben von Pergamentpapier. Chem. Tech. Repertorium. 1:197. 1875.
26. Burr, A. Pergamentpapier und Butterfehler. Molk. Ztg. (Hildesheim) 20: 1105-1106. 1906.
27. ———. The effect of using parchment paper on the quality of butter. Illus. Landw. Ztg. pp. 475-476. 1907. Abstract in Chem. Abstracts 2:331. 1908.
28. ———. Ueber einen durch Berührung mit Pergamentpapier hervorgerufenen Geschmacksfehler der Butter. Milchw. Zentrbl 3:161-168. 1907.
29. ———. Butterfehler, ihre Ursachen und Verhütung. Molk. u. Käserei-Ztg. (Leignitz) 3:11. 1908.
30. ———. Schimmelige Butter infolge Verwendung stark zuckerhaltigen Pergamentpapieres. Molk. Ztg. (Hildesheim) 23:1189-1190. 1909.
31. ———, und Wolff, A. Prüfung von Pergamentpapier auf Brauchbarkeit zum Einschlagen von Butter. Milchw. Zentrbl. 6:241-264. 1910.
32. ———, ———, and Berberich, F. Das Pergamentpapier des Handels. Ztschr. Untersuch. Nahr. u. Genussmtl. 24:197-227. 1912.
33. Davis, L. M. Buttermaking. California Expt. Sta. Rept. p. 48. 1916.
34. Dean, H. H. Report of the Professor of Dairy Husbandry. Ontario Agr. Col. and Expt. Farm Ann. Rept. 30:73-88. 1904.
35. Dekeghel, M. The manufacture of parchment paper. Papyrus 6:498-501, 824-826. 1925. 7:27-30. 1926.
36. Dudderidge, Mary. The bacteriology of paper dishes. Housewives League Mag. 5:12-15. 1915.
37. Fischer, K. Borsäurehaltiges Pergamentpapier. Ztschr. Untersuch. Nahr. u. Genussmtl. 8:417. 1904.
38. Fortini, V., and Ceccherelli, A. Prüfung der Pergamentierten Papiere. Chem. Ztg. 37:237-239. 1913.

39. Gripenberg, R. Untersuchung über Schimmelbildung bei Lagerbutter. Meddel. Mustiala Inst. Forsöksstat. Mejeriafd., Helsingfors, pp. 51. 1899. Abstract in Milch. Ztg. **28**:626-628, 644-646, 662-663. 1899.
40. Hals, S., and Heggenhaugen, S. Some investigations of parchment paper. Norsk. Landmandsblad **32**:369-371. 1913. Abstract in Expt. Sta. Record **30**:179. 1914.
41. Hartig, E. Pergamentpapier kann gegen Oel undurchdringlich gemacht werden. Chem. Tech. Repertorium **1**:160. 1884.
42. Hastings, E. G. Moldy butter and its prevention. Creamery and Milk Plant Mo. **9**:34-37. 1920.
43. Herzberg, W. Zollschwierigkeiten bei Pergamyn- und Pergamentersatzpapieren. Mitt. K. Materialprufungsamt. **29**:464-467. 1911.
44. ————. Unterscheidung zwischen echtem und unechtem Pergamentpapier. Mitt. K. Materialprufungsamt. **30**:407-408. 1912.
45. ————. Die Festigkeit von lufttrocknem und genäsztem Pergamentpapier. Mitt. K. Materialprufungsamt. **32**:539-540. 1914.
46. Holleman, A. F. Textbook of organic chemistry. 5th ed. New York. 1920.
47. Hood, E. G. and White, A. H. The cause and prevention of mold in Canadian pasteurized butter. Dom. of Canada, Dept. of Agr. Bull. 48, N. S. Ottawa. 1925.
48. Huth, F. Die Prüfungen des Pergamentpapiers. Papierfabr. **23**:73-74. 1925.
49. Kolbes, H. Ueber Benzoesäure, Salicylsäure etc. als Antiseptischemittel. Chem. Tech. Repertorium **11**:18. 1874.
50. Kugler, J. G. Anfertigung von kunstlichen Pergament und Pergamentschiefer. Chem. Tech. Repertorium. **1**:198. 1875.
51. Kühl, H. Welche Anforderungen sind an das zum Einwickeln von Lebensmitteln dienende Papier zu Stellen? Pharm. Zentralhalle **50**:1079-1081. 1909.
52. ————.Ueber Pergamentpapier. Molk. Ztg. (Hildesheim) **28**:495-496. 1914.
53. Lachmann, R. Die Prüfung der pergamentierten Papier. Chem. Ztg. **37**:470. 1913.
54. Levine, E. Parchment paper and mold. p. 1104, N.Y. Produce Rev. April 22, 1925.
55. Ludicke, A. Pergamentpapier. Chem. Tech. Repertorium **1**:317. 1876.
56. Luhrig, H. and Wiedmann, F. Borsäurehaltiges Pergamentpapier. Jahresbericht der chem. Untersuchungsamtes Chemnitz 1903. Abstract in Ztschr. Untersuch. Nahr. u. Genussmtl. **8**:430-431. 1904.
57. Minor, J. E. Parchmentizing paper and the reaction of mordants. Science **53**:25. 1921.
58. Postl, H. Pergamentpapier. Tech.-Wiss. Teil Papierfabr. **22**:410-415. 1924.
59. Rogers, L. A. II, Preventing molds in butter tubs. U. S. Dept. Agr. Bur. Anim. Indus. Bull. 89. 1906.
60. Schacht, G. Testing of imitation parchment paper for resistance to grease. Wochenbl. Papierfabr. **42**:3632-3634. 1911. Abstract in Jour. Soc. Chem. Indus. **30**:1026. 1911.
61. Schaeffer, A. Ist ein mit Stärkesirup geschmeidig gemachtes Pergamentpapier zum Verpacken von Butter geeignet? Molkerei- und Käserei Ztg. (Leignitz). No. 36, 1909. Also in Milchw. Zentbl. **6**:527. 1910.
62. Schneider, G. Mit Traubenzucker (Stärkezucker) geschmeidig gemachtes Pergamentpapier als Packmaterial für Speisefette. Ztschr. Spiritus, ind. **35**:289. 1912.

63. Schwalbe, G. and Becker, E. Zur Kenntnis der Zellstoffschleime III. Die Hygroskopizität schleimhaltiger Papiere in mit Wasserdampf gesättigter Luft. Ztschr. Angew. Chem. **33**:58-59. 1920.
64. Schwarz, C. Prüfung von Pergamentpapier. Molk. Ztg. (Berlin) **14**:373-374. 1904.
65. See, P. Sur les moisissures causant l'alteration du papier. Compt. Rend. Acad. Sci. (Paris) **164**:230-232. 1917.
66. Shaw, G. W. A new fungus in butter. Oregon Sta. Press Notes. Nov. 23, 1896.
67. Siegfeld, M. Pergamentpapier für Molkereizwecke. Molk. Ztg. (Hildesheim) **26**:1125-1126. 1912.
68. Sindall, R. W., and Bacon, W. Analyses of vegetable parchments. Chem. Engineer. **21**:75. 1915.
69. ———. Methods of analysing vegetable parchments. Paper Makers' Monthly Jour. Abstract in Chem. News **113**:67-68. 1916.
70. Teichert, K. Aus dem Jahresbericht der Milchwirtschaftlichen Untersuchungsanstalt in Allgau zu Mimmingen, 1907. Chem. Ztg. **32**:496. 1908.
71. Thorpe. Dictionary of applied chemistry. (London), **4**:101-103. 1913.
72. Vieth, P. Untersuchung von Pergamentpapier. Milchw. Zentbl. **2**:480. 1906.
73. Von Boltenstern, O. Mit Stärkesirup geschmeidig gemachtes Pergamentpapier ist zum Verpacken von Butter brauchbar. Ztschr. Spiritusindus. **32**:99-100. 1909.
74. ———. Mit Traubenzucker (Stärkezucker, Stärkesirup geschmeidig gemachtes Pergamentpapier als Packmaterial für Margarine. Ztschr. Spiritusindus. **32**:174-175. 1909.
75. Weiss, H. Pergamentpapiere und Pergamentpapierersatz als Umhüllungen für Lebensmittel. Ztschr. Untersuch. Nahr. u. Genussmtl. **46**:300-306. 1923.
76. Williams, H. E. The action of thiocyantes on cellulose. Jour. Soc. Chem. Indus. **40**:221-224. 1921.